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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/757,764	01/09/2001	Daniel J. Scales	9772-0268-999	8427

22879 7590 11/01/2005

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EXAMINER

YIGDALL, MICHAEL J

ART UNIT PAPER NUMBER

2192

DATE MAILED: 11/01/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 09/757,764	Applicant(s) SCALES, DANIEL J.	
	Examiner Michael J. Yigdall	Art Unit 2192	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 11 August 2005.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-39 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-39 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on August 11, 2005 has been entered. Claims 1-39 are pending.

Response to Arguments

2. Applicant's arguments with respect to claims 1-39 have been considered but are moot in view of the new ground(s) of rejection.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

4. Claims 1, 2, 5, 7-14, 17, 19-26, 29 and 31-39 are rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 5,758,051 to Moreno et al. (art of record, "Moreno") in view of U.S. Patent No. 5,787,287 to Bharadwaj (art of record, "Bharadwaj") in view of U.S. Patent No. 6,077,313 to Ruf (art of record, "Ruf") in view of U.S. Patent No. 6,615,403 to Muthukumar et al. (art now made of record, "Muthukumar").

With respect to claim 1 (currently amended), Moreno discloses a method for modifying serial dependencies in a procedure (see, for example, column 9, lines 38-45).

Although Moreno discloses reordering memory operations and scheduling the associated instructions (see, for example, FIG. 2A), Moreno does not expressly disclose the steps of:

(a) building a graph representation of said procedure, said graph representation having an origin and including a unique position, relative to said origin, for each memory operation in said procedure;

(b) designating a location type for each memory operation in said graph representation; each said location type based on a characteristic of said corresponding memory operation;

However, Bharadwaj discloses step (a) above in terms of building vectors to represent data dependency and control flow paths for instructions in a procedure (see, for example, FIG. 3 and column 3, lines 32-35, and see, for example, FIG. 2 and column 3, lines 50-56, which shows a control flow diagram or graph representation having an origin and a unique position for each memory operation).

Bharadwaj further discloses step (b) above in terms of designating each memory operation according to its associated variable, i.e. location type, and classifying each instruction as a reader or a writer based on its characteristics (see, for example, column 4, lines 4-25).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the system of Moreno with the features taught by Bharadwaj, for the purpose of determining whether reordering memory operations affects the meaning of the source code (see, for example, Bharadwaj, column 6, lines 40-43).

Moreno does not expressly disclose the step of:

(c) generating a summary for each memory operation in the graph representation that indicates for each location type used in the procedure the closest preceding memory operation to affect the location type;

However, Ruf discloses building a dependence graph to represent each location type used in a procedure (see, for example, column 9, lines 40-49), and using the graph, a summary indicating the location type of each node, to determine the ordering of types and dependencies with data flow analysis (see, for example, column 9, line 66 to column 10, line 21). Note that the ordering would indicate for each node or memory operation the closest preceding node or memory operation for that type.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the system of Moreno with the features taught by Ruf, for the purpose of partitioning the data flow analysis by location type to minimize the execution time and memory space requirements (see, for example, Ruf, column 10, lines 31-58).

Bharadwaj further discloses the step of:

(d) identifying a first memory operation having the same location type as a second memory operation; wherein said first memory operation is positioned closer to said origin than said second memory operation, and said graph representation does not include any additional memory operations of the same location type between the first and second memory operations (see, for example, column 5, lines 3-5, which shows computing the dependency path vector between two instructions that operate on the same variable, i.e. that have the same location type, and see, for example, column 4, lines 52-58, which shows that one memory operation comes

Art Unit: 2192

before the other, i.e. that one memory operation is closer to the origin, and column 5, lines 5-10, which shows that no related instructions are included between the two memory operations).

Moreno further discloses the step of:

(e) moving said second memory operation to a new position in said graph representation that is closer to said first memory operation (see, for example, column 9, lines 55-67, which shows moving a second memory operation to an earlier position, i.e. closer to a first memory operation).

Moreno does not expressly disclose the limitation wherein the moving step includes (i) removing one or more of the serial dependencies in an initial set of serial dependencies that is associated with said second memory operation and (ii) creating a new serial dependency between said first memory operation and said second memory operation.

However, Muthukumar discloses removing a serial dependency and creating a new serial dependency in a data dependence graph (see, for example, column 4, lines 37-44), such as in a graph that includes first and second memory operations (see, for example, FIG. 4B and column 5, lines 5-12 and 33-39). This improves scheduling flexibility and execution efficiency (see, for example, column 6, lines 6-14), as compared to the reduced performance that would result from the initial set of serial dependencies (see, for example, column 2, lines 40-48).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the system of Moreno with the features taught by Muthukumar, for the purpose of improving the flexibility in moving and scheduling the memory operations.

With respect to claim 2 (currently amended), Bharadwaj further discloses the limitation wherein:

(a) the building step includes the step of assigning an initial set of serial dependencies between program operations represented in said graph representation (see, for example, column 6, lines 51-54, which shows computing an initial set of dependency path vectors between instructions).

With respect to claim 5 (original), Moreno further discloses the limitation wherein said moving step results in said second memory operation being advanced in a schedule of machine instructions (see column 9, lines 55-67, which shows moving a second memory operation to an earlier position, i.e. advancing the operation in the schedule of instructions).

With respect to claim 7 (original), Moreno further discloses the limitation wherein said first memory operation is a store or an array store and said second memory operation is a load or an array load (see, for example, column 9, lines 63-67, which shows the case wherein the second memory operation is a load and the first memory operation is a store).

With respect to claim 8 (original), Moreno further discloses the limitation wherein said procedure includes a calling procedure and said first memory operation is in said calling procedure and said second memory operation is in a called procedure that is called by an operation in said calling procedure (see, for example, column 9, lines 33-48, which shows scheduling all the instructions in a program, including those associated with a procedure called by another procedure; note that a calling procedure may include a first memory operation and a called procedure may include a second memory operation).

With respect to claim 9 (original), Moreno further discloses the limitation wherein said moving step results in a placement of said second memory operation in said calling procedure (see, for example, column 9, lines 33-48, which shows moving a second memory operation to an earlier position in the schedule of instructions; note that this applies to all the instructions in a program, and could result in moving a second memory operation from a called procedure to a calling procedure).

With respect to claim 10 (original), Bharadwaj further discloses the limitation wherein said location type of each memory operation is selected from the group consisting of a predefined set of base types, a predefined set of array types, object types, and object field types (see, for example, column 4, lines 4-15, which shows identifying memory operations that reference a particular variable, i.e. memory operations associated with the same data type; note that the data type or location type of a variable is necessarily selected from a predefined set of base types and array types, or from a set of object types and object field types defined in the code).

With respect to claim 11 (original), Bharadwaj further discloses the limitation wherein the building step further comprises adding a global store dependency to each operation in said procedure that reads a variable from or stores a variable to memory (see, for example, column 4, lines 4-15, which computing dependency path vectors for each instruction that reads or writes a variable; note that a store dependency would be added to each operation following a store instruction that references the same variable).

Moreno further discloses the step of:

(a) generating a schedule of machine instructions in accordance with said graph representation, wherein each said machine instruction in said schedule of machine instructions, which corresponds to an operation that reads a variable from or stores a variable to memory, is ordered in accordance with said global store dependency associated with said operation (see, for example, FIG. 1, which shows generating a schedule of instructions, and column 9, lines 59-67, which shows verifying that memory operations are ordered in accordance with a store dependency).

With respect to claim 12 (original), Bharadwaj further discloses the limitation wherein a first operation affects a value of a variable stored in memory and a second operation serially follows said first operation, said building step further comprising adding a global store dependency from said second operation to said first operation (see, for example, column 4, lines 4-15, which shows computing dependency path vectors for each instruction that reads or writes a variable; note that a store dependency would be added from a second operation to a first operation when both instructions reference the same variable).

Moreno further discloses the step of:

(a) generating a schedule of machine instructions in accordance with said graph representation, wherein said machine instructions in said schedule of machine instructions corresponding to said second operation are scheduled after said machine instructions corresponding to said first operation (see, for example, FIG. 1, which shows generating a schedule of instructions, and column 10, lines 50-60, which shows ensuring that instructions are executed in the order prescribed by the dependencies).

With respect to claim 13 (currently amended), the limitations recited in the claim are analogous to those of claim 1 (see the rejection of claim 1 above). Note that Moreno further discloses a computer program product for use in a computer system (see, for example, column 1, lines 18-22).

With respect to claim 14 (currently amended), the limitations recited in the claim are analogous to those of claim 2 (see the rejection of claim 2 above).

With respect to claim 17 (original), the limitations recited in the claim are analogous to those of claim 5 (see the rejection of claim 5 above).

With respect to claim 19 (original), the limitations recited in the claim are analogous to those of claim 7 (see the rejection of claim 7 above).

With respect to claim 20 (original), the limitations recited in the claim are analogous to those of claim 8 (see the rejection of claim 8 above).

With respect to claim 21 (original), the limitations recited in the claim are analogous to those of claim 9 (see the rejection of claim 9 above).

With respect to claim 22 (original), the limitations recited in the claim are analogous to those of claim 10 (see the rejection of claim 10 above).

With respect to claim 23 (original), the limitations recited in the claim are analogous to those of claim 11 (see the rejection of claim 11 above).

With respect to claim 24 (original), the limitations recited in the claim are analogous to those of claim 12 (see the rejection of claim 12 above).

With respect to claim 25 (currently amended), the limitations recited in the claim are analogous to those of claim 1 (see the rejection of claim 1 above). Note that Moreno further discloses a computer system comprising a memory and a processor (see, for example, FIGS. 3 and 5).

With respect to claim 26 (currently amended), the limitations recited in the claim are analogous to those of claim 2 (see the rejection of claim 2 above).

With respect to claim 29 (original), the limitations recited in the claim are analogous to those of claim 5 (see the rejection of claim 5 above).

With respect to claim 31 (original), the limitations recited in the claim are analogous to those of claim 7 (see the rejection of claim 7 above).

With respect to claim 32 (original), the limitations recited in the claim are analogous to those of claim 8 (see the rejection of claim 8 above).

With respect to claim 33 (original), the limitations recited in the claim are analogous to those of claim 9 (see the rejection of claim 9 above).

With respect to claim 34 (original), the limitations recited in the claim are analogous to those of claim 10 (see the rejection of claim 10 above).

With respect to claim 35 (original), the limitations recited in the claim are analogous to those of claim 11 (see the rejection of claim 11 above).

With respect to claim 36 (original), the limitations recited in the claim are analogous to those of claim 12 (see the rejection of claim 12 above).

With respect to claim 37 (previously presented), Ruf further discloses the limitation wherein no known preceding memory operation in the procedure affects a location type, said summary indicates the origin for that location type (see, for example, column 9, lines 40-49, which shows building a dependence graph to represent each location type used in a procedure, and column 9, line 66 to column 10, line 21, which shows using the graph, a summary indicating the location type of each node, to represent the ordering of types and dependencies in a directed acyclic graph; note that a node for which no known preceding memory operation affects its location type will be indicated as an origin for that location type in the ordered graph).

With respect to claim 38 (previously presented), the limitations recited in the claim are analogous to those of claim 37 (see the rejection of claim 37 above).

With respect to claim 39 (previously presented), the limitations recited in the claim are analogous to those of claim 37 (see the rejection of claim 37 above).

5. Claims 3, 4, 15, 16, 27 and 28 are rejected under 35 U.S.C. 103(a) as being unpatentable over Moreno in view of Bharadwaj in view of Ruf in view of Muthukumar, as applied to claims 1, 13 and 25 above, respectively, and further in view of U.S. Patent No. 6,016,398 to Radigan (art of record, "Radigan 398").

With respect to claim 3 (original), Moreno does not expressly disclose the limitation wherein said graph representation is an intermediate representation.

However, Radigan 398 discloses the limitation above in a system for removing dependencies (see, for example, FIG. 2A, which shows creating an intermediate representation of a program comprising nodes for a graph), in order to ensure that each variable expression will be reached by at most one definition (see, for example, column 6, lines 56-61).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the system of Moreno with the features taught by Radigan 398, for the purpose of ensuring the consistency of variable definitions.

With respect to claim 4 (original), Moreno does not expressly disclose the limitation wherein said intermediate representation is a single static assignment graph embedded in a control flow graph.

However, Radigan 398 further discloses the limitation above (see, for example, FIG. 4A, which shows determining the flow of control along each execution path, and FIG. 3A and column 14, lines 14-16, which shows a corresponding graph, and see, for example, column 6, lines 56-61, which shows using static single assignment or SSA in order to ensure that each variable expression will be reached by at most one definition).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the system of Moreno with the features taught by Radigan 398, for the purpose of ensuring the consistency of variable definitions.

With respect to claim 15 (original), the limitations recited in the claim are analogous to those of claim 3 (see the rejection of claim 3 above).

With respect to claim 16 (original), the limitations recited in the claim are analogous to those of claim 4 (see the rejection of claim 4 above).

With respect to claim 27 (original), the limitations recited in the claim are analogous to those of claim 3 (see the rejection of claim 3 above).

With respect to claim 28 (original), the limitations recited in the claim are analogous to those of claim 4 (see the rejection of claim 4 above).

6. Claims 6, 18 and 30 are rejected under 35 U.S.C. 103(a) as being unpatentable over Moreno in view of Bharadwaj in view of Ruf in view of Muthukumar, as applied to claims 1, 13 and 25 above, respectively, and further in view of U.S. Patent No. 6,151,704 to Radigan (art of record, "Radigan 704").

With respect to claim 6 (original), Moreno does not expressly disclose the limitation wherein said first memory operation is positioned before a repetitive loop in said procedure and said second memory operation is within said repetitive loop; said graphic representation including a phi node that corresponds to a loop back position in said repetitive loop.

However, Radigan 704 discloses the limitation above for the purpose of optimizing a loop in a computer program (see, for example, column 6, lines 3-11, which shows a memory operation within a loop and a memory operation prior to the loop, and see, for example, column

4, lines 32-36, which shows the use of phi functions or phi nodes to denote a merge point, such as a loop back position).

Radigan 704 further discloses the limitations wherein:

(a) when a memory operation having the same location type as said first and second memory operation exists in said loop, said new position in said graph representation is a position that is serially dependent upon said phi node (see, for example, column 6, lines 3-11, which shows determining whether a memory operation writes to a variable referenced by the first and second memory operations, and thus has the same location type and is dependent upon the phi node); and

(b) when a memory operation having the same location type as said first and second memory operation does not exist in said loop, said new position in said graph representation is a position that is not serially dependent on any operation in the loop (see, for example, column 6, lines 3-11, which shows determining whether a memory operation is not within the loop and thus is not dependent upon instructions in the loop).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the system of Moreno with the features taught by Radigan 704, for the purpose of optimizing loops in a computer program.

With respect to claim 18 (original), the limitations recited in the claim are analogous to those of claim 6 (see the rejection of claim 6 above).

With respect to claim 30 (original), the limitations recited in the claim are analogous to those of claim 6 (see the rejection of claim 6 above).


Conclusion

7. The prior art made of record and not relied upon is considered pertinent to Applicant's disclosure. U.S. Patent No. 6,487,716 to Choi et al. discloses methods and apparatus for optimizing programs in the presence of exceptions. U.S. Patent No. 6,918,111 to Damron et al. discloses a system and method for scheduling instructions to maximize outstanding prefetches and loads. U.S. Patent No. 5,850,552 to Odani et al. discloses an optimization apparatus for removing hazards by arranging instruction order.

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Michael J. Yigdall whose telephone number is (571) 272-3707. The examiner can normally be reached on Monday through Friday from 7:30am to 4:00pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Tuan Q. Dam can be reached on (571) 272-3695. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).


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Application/Control Number: 09/757,764
Art Unit: 2192

Page 16

MY

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Art Unit 2192

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